Control of Methane Emissions for Ozone Air Quality Purposes

J. Jason West[1,2], Arlene M. Fiore[3], Larry W. Horowitz[3], and Denise L. Mauzerall[2]
[1] Program in Atmospheric & Oceanic Sciences, Princeton University
[2] Woodrow Wilson School of Public & International Affairs, Princeton University
[3] Geophysical Fluid Dynamics Laboratory

Ozone is a widespread air pollutant that adversely affects human health, agricultural productivity, and natural ecosystems. Global background concentrations of ozone are sensitive to NO_x and methane emissions, yet methane control is currently considered only for climate purposes. Here we consider whether methane mitigation can be justified for air quality purposes, by considering the costs of methane control and the benefits of reduced ozone, focusing on human health.

The steady-state reduction in surface ozone concentration resulting from a 50% decrease in global anthropogenic methane emissions is estimated to be ~3 ppb, using global 3-D models of tropospheric chemistry. These ozone reductions are widespread globally (Figure 1) and are realized gradually, following the 12 year perturbation lifetime of methane. In contrast, conventional controls on NO_x and NMVOCs affect ozone rapidly and target high-ozone episodes in polluted regions, but have less benefit for climate.

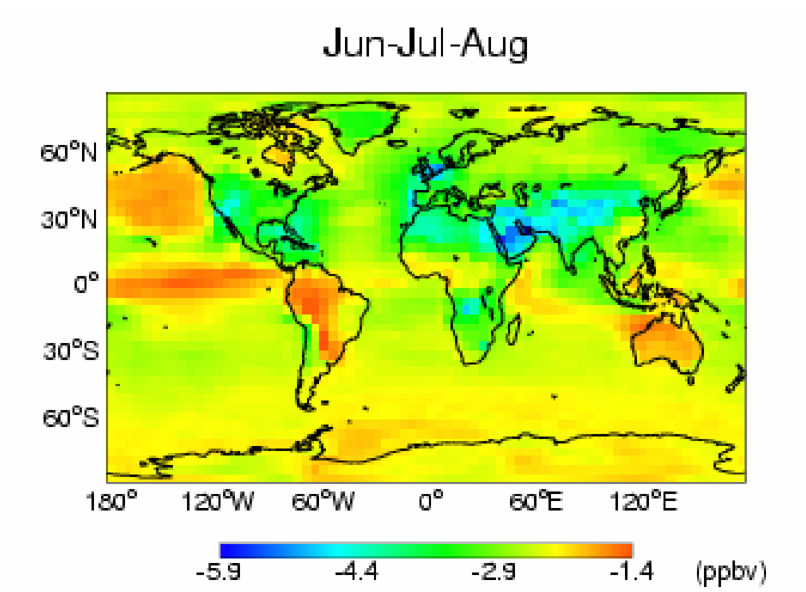

Figure 1 – Global change in mean summer (June-July-August) afternoon (1300 to 1700 local time) surface ozone (ppb) ultimately achieved when anthropogenic methane emissions are decreased by 50% in the GEOS-CHEM tropospheric chemistry model (driven by assimilated meteorology for 1995 from NASA GEOS-1 at 4°x5° horizontal resolution), as described by Fiore *et al.* (2002).

The modeled sensitivity of ozone to methane emission reductions is then combined with estimates of methane control costs and of the health and agricultural benefits of ozone reductions. Approximately 10% of global anthropogenic methane emissions can be reduced by 2010 at a net cost-savings (due to the recovery of methane as a fuel), according to two compilations of the available global methane emission reductions, which focus on industrial sources (IEA, 2003; EPA, 2003). We estimate that implementing these identified cost-saving measures will reduce ozone by 0.4-0.7 ppb. A coarse estimate of the monetized global benefits of ozone reductions for agriculture, forestry, and human health (neglecting ozone mortality) justifies reducing ~17% of global anthropogenic methane emissions (West and Fiore, submitted). These benefits of methane mitigation are comparable to previous estimates of the ancillary benefits for air quality and human health of CO_2 mitigation.

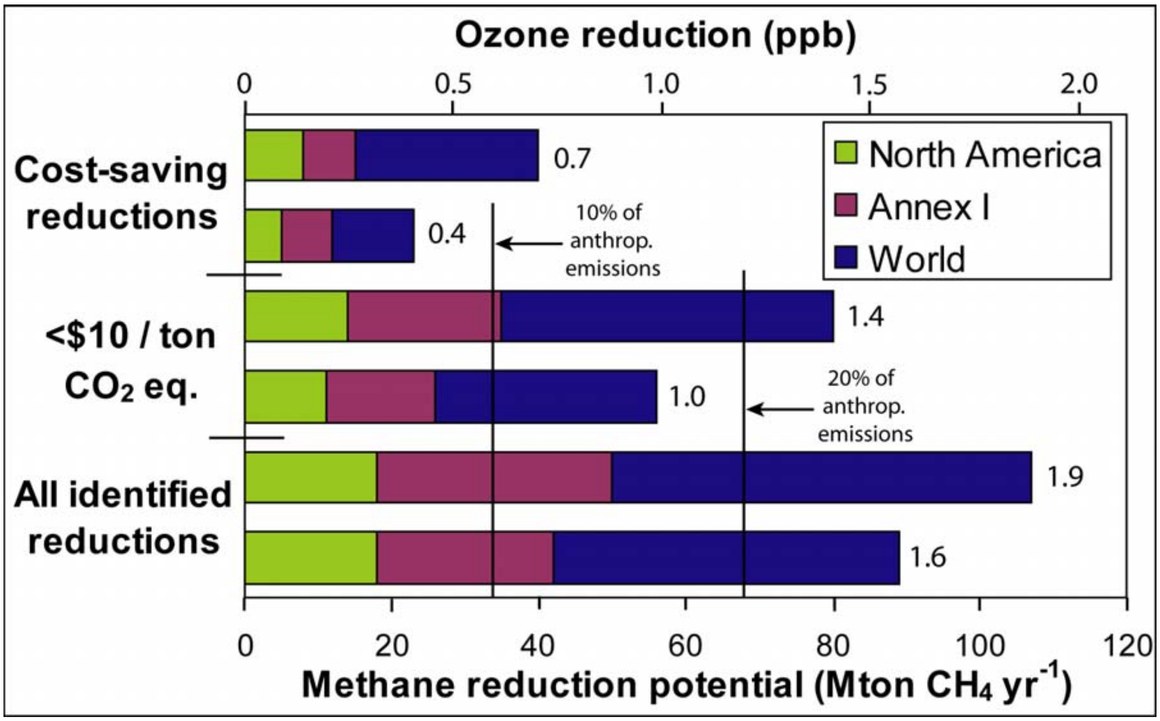

Figure 2 – Methane emission reduction potential in 2010, estimated by IEA (2003; top bar of each pair) and EPA (2003; lower bar), and the resulting estimated reductions in Northern Hemisphere summer surface ozone ultimately achieved if the available methane reductions are implemented. The ozone reductions would be fully achieved after more than 20 years. Reductions in winter and in the Southern Hemisphere are slightly smaller. Annex I refers to all nations in Annex I of the United Nations Framework Convention on Climate Change. For EPA at <$10 / ton CO_2 eq., we used their estimates for $200 / ton CH_4, which is $9.5 / ton CO_2 eq. using their global warming potential of 21. Percents are relative to current global anthropogenic emissions, taken as 340 Mton CH_4 yr^{-1}.

We next estimate the global reduction in premature human deaths resulting from decreases in methane emissions, based on epidemiological studies relating daily mortality to ozone concentration. We consider a baseline scenario from 2000 to 2030 (based on the A2 scenario used in the IPCC AR-4 atmospheric chemistry experiments) and apply a 20% reduction of global anthropogenic methane emissions versus this baseline. The simulated spatially-distributed decreases in surface ozone concentrations from the MOZART-2 model (Horowitz *et al.*, 2003) are combined with estimates of future population consistent with the A2 scenario. Our preliminary results suggest that the global reductions in premature mortality are substantial, justifying additional methane reductions beyond the 17% calculated above when human mortality was neglected.

Our results indicate that methane emission control is viable for long-term ozone management, with benefits that are shared globally. Methane emission control is therefore a powerful lever for addressing both global air pollution and climate change, through decreases in background tropospheric ozone. Increased emphasis on international methane controls should be considered alongside NO_x and NMVOC controls in air quality planning.

References

Fiore, A.M., D.J. Jacob, B.D. Field, D.G. Streets, S.D. Fernandes, and C. Jang, Linking ozone pollution and climate change: The case for controlling methane, *Geophys. Res. Lett., 29(19)*, 1919, 2002.

Horowitz, L. W., S. Walters, D. L. Mauzerall, L. K. Emmons, P. J. Rasch, C. Granier, S. Tie, J.-F. Lamarque, M. G. Schultz, G. S. Tyndall, J. J. Orlando, and G. P. Brasseur (2003) A global simulation of tropospheric ozone and related tracers: Description and evaluation of MOZART, version 2, *Journal of Geophysical Research*, 108(D24): 4784, doi:10.1029/2002JD002853.

International Energy Agency Greenhouse Gas R&D Programme. *Building the Cost Curves for the Industrial Sources of Non-CO_2 Greenhouse Gases*, Report No. PH4/25, 2003.

US Environmental Protection Agency. *International Analysis of Methane and Nitrous Oxide Abatement Opportunities: Report to the Energy Modeling Forum, Working Group 21*, www.epa.gov/methane/pdfs/methodologych4.pdf, 2003.

West, J.J., and A.M. Fiore, Management of tropospheric ozone by reducing methane emissions, *Environ. Sci. & Technol*., submitted.